INTI JOURNAL | eISSN:2600-7320
Vol.2019:51

Investigation on Transforming of a Fixed Gas Analyser into a Portable Emission Measurement System (PEMS)

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Abstract

Recently Portable Emission Measurement System (PEMS) is being used to show the real emission components of diesel engines (and petrol engines) instead of using test cycles because of their more realistic measurements. Their drawback is their high price and unavailability. This study investigates the possibility of transforming a fixed gas analyser that cost approximately RM50,000 into a PEMS. The project was done through the simulation of a program coded using Python to imitate the functions of a PEMS as close as possible. In the code, it is programmed to calculate emission from a diesel-based vehicle, based on the changes of the Torque and RPM. Simulation of the code uses data from a research paper reviewed. The difference of the project simulation and the research paper data is 6.32%. It is concluded there is a possibility as the code was able to be validated.

Introduction

In the current era, air pollution has posed a huge threat towards humanity and one of the main causes of air pollution is through vehicle emissions. Many countries face air pollution problems caused by vehicle gas emissions. As stated by the World Health Organization (WHO), air pollution has been a major cause for many deaths along with diseases world-wide. The main culprits for the concerns of public health are the particles such as the particulate matter and the nitrogen dioxide which are partly produced by vehicle emissions. Moreover, nearly 28% of the greenhouse gas emissions were from the transportation sector.

The United States Environmental Protection Agency (US EPA, 2019) stated that burning fossil fuels for all transportation vehicles were the primary source for the greenhouse gas emissions. For the cases found in Malaysia, in the year 2015, the main source of air pollution was by vehicle emissions. The total contribution was up to 2.1 million tonnes of air pollution. During this period, the total number of registered vehicles was about 26.3 million and the number of

International Conference on Innovation and Technopreneurship 2019
Submission: 14 June 2019; Acceptance: 17 July 2019

registered vehicles continues to increase, which leads to more contribution of air pollution every year (Compendium of Environment Statistics (CES), Malaysia, 2016).

Controlling these emissions requires standards to be made. An example would be that in the European countries, there exist standards called Euro 1 to 6 and these standards are strict. If a certain manufacturer of motor vehicles does not comply with these standards, their vehicles are not allowed to be sold in European countries. To comply with these standards made, emission testing needs to be done. Though there are many types of emission test, the test most related to this project is the Real Driving Emission (RDE) Test which requires the use of a Portable Emission Measurement System (PEMS). There are drawbacks found on the PEMS and the drawbacks are that they are of high price and is hard to be acquired. The price of a single PEMS is approximately more than a million and this project's objective is to research on the possibilities of transforming a Fixed Gas Analyzer, which cost around ten thousand, into a PEMS.

In this study, a program code is developed to investigate the possibility of transforming a fixed gas analyser into a portable emission measurement system (PEMS). To validate this program code, real experimental data on the vehicle engine torque and rpm, of a certain WLTC test drive will be processed by the program code and output data of when the emissions are calculated will be produced.

Methodology

In the present paper, a simulation to imitate a Portable Emission Measurement System (PEMS) was done. Simulation will be in program code structure and is constructed using a software called PyCharm which uses the Python programming language. To ensure that the program is working, a set of data is needed for the input. The data that is used for the program code is a data obtained from an article paper by one of the researched papers written by Giakoumis and Zachiotis ("Analysis of the Effect of Vehicle, Driving and Road Parameters on the Transient Performance and Emissions of a Turbocharged Truck", 2018). The article is an investigation on the performance and emissions of a Diesel-Engine during a WLTC driving cycle.

The code is split into two parts with Part A being the process of detecting the engine change and then determining whether to send a signal to collect emission, to the fixed gas analyser or not. Part B is the process of collecting that signal and sending it to the gas analyser to allow for the fixed gas analyser to start the emission collection. After running the program code with the data provided, the program code successfully produced the data of when emission is calculated based on the changes in torque and rpm. The code assigns "ones" and "zeros" for when emission is calculated or not. All the data of "ones" and "zeros" were collected and then processed to keep only the values found to be in the interval of 10 seconds starting from the initial first "zero" second through the coding of Part B. This is to ensure a more realistic data as a fixed gas analyser may not able to completely collect an emission within a single second.

Results and Discussion

The expected outcome of this project is to show whether the fixed gas analyser is able to collect emission while on road based on the changes of the engine only, using the code constructed as simulation and produce an almost similar results with the portable emission measurement system. The processed output data can be seen in Table 1.

Table 1. Processed output data for 10 second interval.

Time(s)	Emission Calculated (Y=1/N=0)	Emission Collected Points
0	1	1
1	0	
2	0	
3	0	
4	0	
5	0	
6	0	
7	0	
8	0	
9	0	
10	0	Not Recorded
11	0	
12	0	
13	0	
14	1	
15	1	
16	1	
17	1	
18	1	
19	1	
20	1	1

The emission collection data is then plotted alongside with the torque and rpm as shown in Figure 1. The “X” marks are the points where emission is calculated for every 10 second interval. When there are no changes in torque and rpm, the emission is not calculated and is set to be the same as the previous emission calculated before.

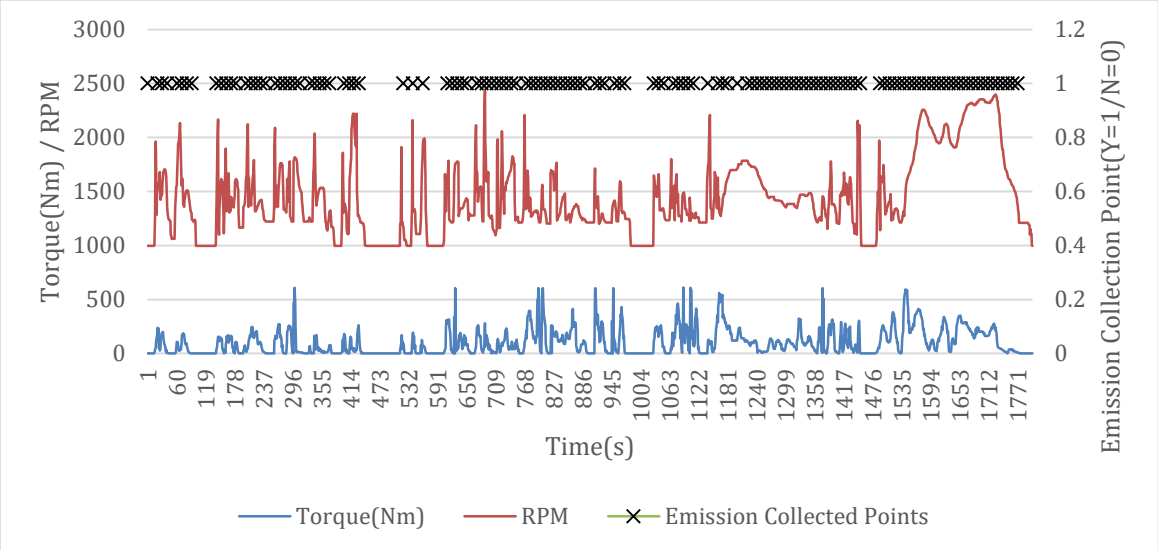

Figure 1. Emission collected points based on torque and RPM.

Compare to the emission data found in the previous researched papers by (Giakoumis and Zachiotis, 2017), the code shows the possibility of transforming the fixed gas analyser into a portable measurement system. When the CO_2 remains constant, the "emission collection" data does not show to be collecting emission and when there is an upward spike in the CO_2, there is an "X" mark on the emission collection point. The same can be said for the Soot and Nitrogen Oxide (NO) graph. In Figure 2 shown the graph of the CO_2 emission along the whole cycle of 1800 seconds. The total amount of CO_2 emission calculated was found to be 5984.63504 g/km after totaling up the emission.

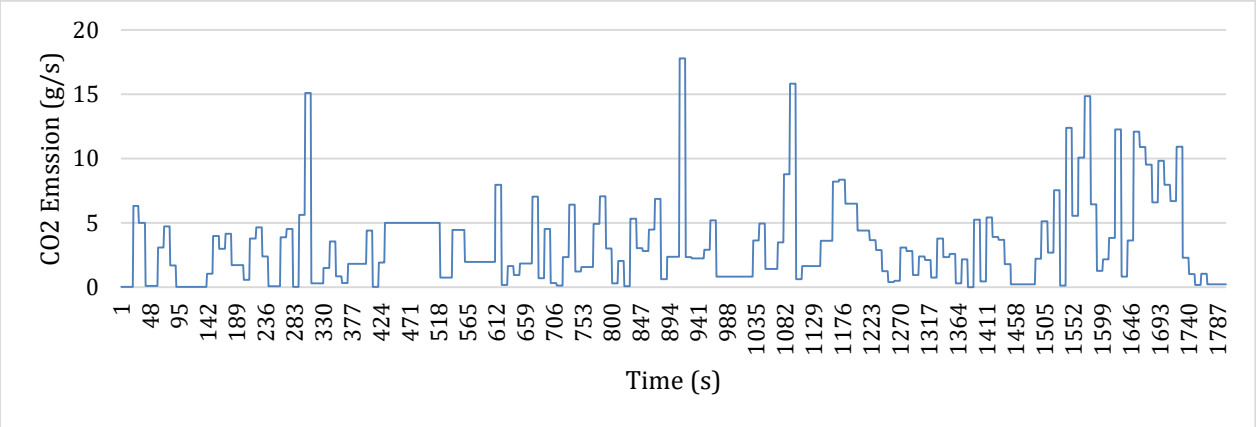

Figure 2. CO_2 Based on emission collected points.

Moreover, from the results obtained through this project, which is the total emission calculated throughout the simulation, the percentage error to determine how close the simulation results with the actual is done. It is found that an error of 6.3 % is found.

Conclusions

From the researches done, it is found that air pollution is a huge threat towards the future of humanity and with the continuous growth and arrival of new vehicles, emissions produced will continue to increase. Thus, finding ways to reduce the emission is important and one the ways is by conducting emissions test which requires the use of a Portable Emission Measurement System.

After the researches and testing were done on the code simulation, the code has been validated. It is concluded that there is the possibility of transforming the fixed gas analyser into a PEMS. The simulation code has managed to detect changes in the torque and rpm and determine when emission is to be taken. Although there is an error of 6.3% as compared to other work and researches, further improvements can be done towards the code through certain recommendations and future works.

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